AGE CHANGES IN THE LIPOFUSCIN CONTENT OF THE HUMAN HEART MUSCLE

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The question of the role and deposition conditions of lipofuscin has not yet been solved.

The most widespread opinion is that regarding lipfuscin as a typical sign of aging [3, 4, 8], as the "slag" of cell metabolism [1, 8]. Pathologicoanatomists, as Vail [2] observed, often relate brown pigmentation of organs to dystrophic changes. On the other hand, some authors [5, 6, 11] consider lipofuscin to be a substance or structure of functional-physiological importance. The necessity of reexamining the hypothesis that lipfuscin is an expression of body involution ("old age pigment," "depreciation pigment") has recently been emphasized in a series of works [2, 6].

A knowledge of the age dynamics of pigmentation, which has certainly not been sufficiently investigated yet, is needed to evaluate the role of lipofuscin. The majority of the existing works [6, 7] do not give a quantitative analysis of the age changes in pigmentation and do not show the procedural features of the processes during the successive periods of individual development. The results of researches [8-10] using the quantitative method are very contradictory.

The purpose of this work was to make the existing data on the age dynamics of brown myocardial pigmentation more exact by using an exact method of quantitative lipofuscin determination on the material and processing the results statistically.

EXPERIMENTAL METHODS

To examine the age dynamics of myocardial pigmentation, we examined 100 hearts from human cadavers of different ages ranging from 28-week old embryos to 82-year old people. All the material was divided into 10-year age groups: from 0 to 9 years, 5 cases; from 10 to 19, 6 cases; from 20 to 29 years, 21 cases; from 30 to 39 years, 18 cases, from 40 to 49 years, 18 cases; from 50 to 59 years, 12 cases; from 60 to 69 years, 10 cases and from 70 to 79 years and over, 10 cases.

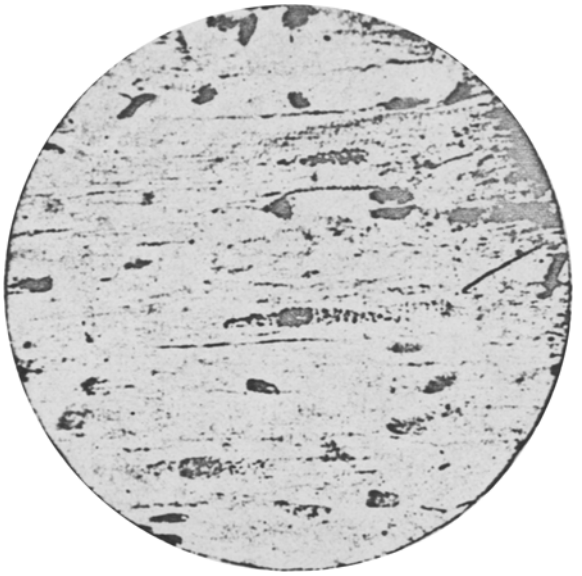
The lipofuscin content was determined by planometric measurement.

The pigment content in the myocardium was determined in the following manner. From the anterior wall of the left myocardial ventricle, sections were made on a freezing microtome. The stains used were Sudan III and hematoxylin. The sections were imbedded in glycerinated gelatine. With the aid of a drawing apparatus, drawings were made of the nuclear contours from the preparations and of the pigment adjoining them, which, in the myocardium, was deposited like clearly-defined cones at each pole of the nucleus (see Figure). From each heart, the contours of 80 pigment cones and of 40 nuclei were drawn. The area of the drawn cones was measured by a planimeter. Then the average area of the perinuclear, pigment cones in each of the experimental myocardia

and the average area of lipofuscin deposition for each age group were determined.

The numerical data obtained were processed statistically to verify the established age differences.

The advantage of this method over those used in previous works (visual comparison of lipofuscin content in the sections [3], correlation of number of strongly and weakly pigmented cells [12], linear measurements [8, 9]) was that it made it possible to measure the area occupied by the lipofuscin deposits and therefore to obtain exact numerical data on the degree of pigmentation in each individual case and in the whole age group.



Heart Muscle with Lipofuscin Deposits

EXPERIMENTAL RESULTS

The following was established from the research conducted. There was no pigment in children up to 9 years old; pigment was found in four out of the six hearts examined in the age group 10-19 years, but not in hearts less than 12 years old; pigment was found in every case in the other age groups. Therefore, lipofuscin was discovered in the myocardium of each cadaver over 12 years old, both in those which had died from trauma and in those which had died from various diseases. Since most of the cadavers had been generally healthy people, this confirms that the pigmentation is not caused by pathological factors and that it should rather be considered a general physiological rule, since lipofuscin is present in the myocardium after the beginning of the second decade.

The lipofuscin content was determined in the hearts of the different age groups in order to evaluate the subsequent course of the pigmentation process (Table 1).

TABLE 1

Change in Lipofuscin Content in People of Different Ages

Group	I	II	III	IV	V	VI	VII	VIII
Age (in years)	0—9	10—19	20—29	30—39	40—49	50—59	60—69	70—79
Average area of lipofuscin deposit (in units of planimetric scale)	—	124	200	270	310	317	300	342
Fluctuation limits	—	77—221	117—343	160—339	203—458	138—501	180—410	204—447

As Table 1 shows, the myocardial lipofuscin content increases with age, attaining the maximum during old age. Great individual variations were observed within each age group, often exceeding the average pigment content in the succeeding age groups.

In order to have a complete picture of the age dynamics of pigmentation, the intensity of pigment accumulation at different stages of individual development had to be determined. The absolute increase of the average area of the lipofuscin cones in each age group as compared with the preceding group was used as the index. Comparing the increases (Table 2) showed that the most intense accumulation of lipofuscin occurred during the first years after its appearance. For example, the average pigment area in Age Group II was 124 units when the highest age group's average was 342 units, i.e., Group II was already almost 40% of the average area in Age Group VIII. Therefore, the period from 10-19 years was characterized by intense pigmentation, which was also observed in Age Groups III and IV, while the intensity of lipofuscin deposition sharply decreased in the succeeding, older age groups.

TABLE 2

Intensity of Lipofuscin Deposition at Different Ages

Group	I	II	III	IV	V	VI	VII	VIII
Age (in years)	0—9	10—19	20—29	30—39	40—49	50—59	60—69	70—79
Increase of lipofuscin area (in units of planimetric scale)	—	124	76	70	40	7	—17	42

The data obtained indicate that the amount of lipofuscin actually increases with age, but that, contrary to present opinion, [3, 8] the greatest intensity of pigment deposition occurs during the first half of life, while pigment deposition decreases during old age.

The amount of pigment increases especially during the first years after its appearance.

The great increase in the amount of lipofuscin during the initial period of individual development and the gradual decrease in pigmentation intensity during the subsequent years would seem to contradict the idea of lipofuscin as an "old age pigment" [3, 4, 8] connected with senile involution. The presence of the pigment cannot be considered an index of old age change, since its accumulation occurs primarily during that period of develpment when the body is still only approaching morphological and functional maturity. The proposition that lipofuscin is functionally and physiologically important is more probable. The present, widely-held "slag theory" [1, 4, 9], which considers the brown pigment to be the useless waste of cell metabolism, accumulating with age, is the wrong basis on which to study further the properties and role of lipofuscin.

SUMMARY

Ontogenetic dynamics of lipfuscin in the human heart muscle were studied by the method of planimetric measurements. The hearts of one hundred cadavers of the age from 28 weeks up to 82 years were investigated. Beginning with the second decade of life lipofuscin is present on the myocardium of every individual, no matter what the cause of his death was: an occasional trauma or an infectious disease. Deposition of lipofuscin is most intense during the first half of the life span (up to 40 years), most of all, at the beginning of its appearance. Data collected indicate that lipofuscin deposition is a physiological phenomenon and is not caused by aging processes of the organism.

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